Limiting insecticide disruption to on farm ecosystem services.

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Why do we need less disruptive insecticides?

Central to Integrated Pest Management (IPM), as practised in Australian broadacre farming, is monitoring that underpins biological, cultural and chemical control of invertebrate communities.

These communities comprise of beneficial species that provide services such as pollination, increasing soil porosity and pest control (natural enemies). However, some invertebrates threaten crop production, which are referred to as pests.

Contamination of and/or damage to grain has become a bigger problem: for example, damage due to any insect such as Pea Weevil, Etiella grub and Heliothis eating the seed coat or more commonly, the kernel are considered defective with a max tolerance of 1.5% by weight for faba beans. Markets and consumers are increasingly conscious and demanding of foods free of chemical residues while also free of pest and disease damage.

The importance of IPM is reducing reliance on insecticides by utilising biological controls.

Diverse farm ecosystems are considered more functional due the presence of natural enemies and will be enhanced by using less disruptive crop protectants.

Figure 1: Predatory bug

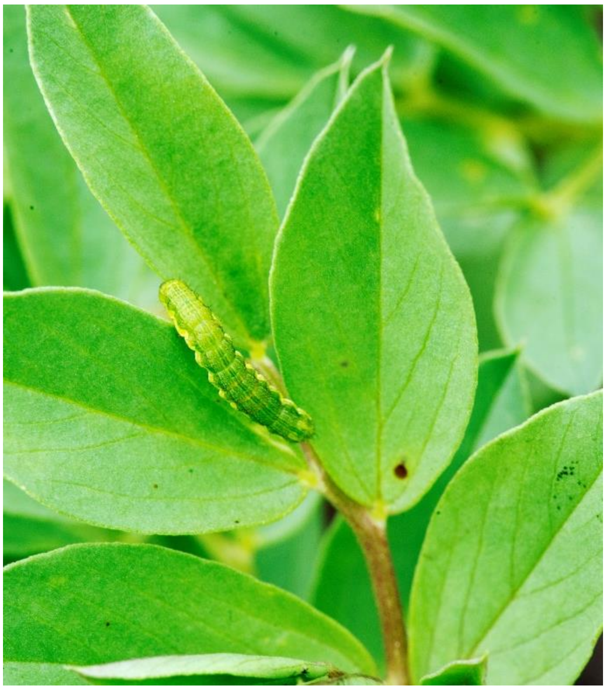

Figure 2: Heliothis (native budworm).

Which insecticides are disruptive to natural enemies?

Enhancing natural enemies is a cornerstone of IPM. Awareness of their function in the grain industry and the impacts of insecticide application/s is increasing. Some insecticides hinder pest management by removing natural enemies, such as predators and parasitoids, from the paddock.

To assist growers and advisors in making informed choices around insecticide use in Australian grain crops, the below table summarises the toxicity of foliar chemical sprays on key beneficial insects (Table 1). To produce this table, Cesar Australia has collected new data through laboratory testing and compiled this with previous research. Research to fill remaining data gaps is ongoing.

Ratings for toxicity are based on International Organisation for Biological Control (IOBC) protocols for laboratory studies and reflect percent mortality of insects within a particular beneficial group exposed to each chemical. A rating of L represents <30% mortality, M 30 - 79%, H 80-99% and VH >99% mortality. Impacts may vary in the field, especially if multiple applications of a chemical occur.

Table 1. List of commonly applied insecticides registered to limit insect damage in pulses. Data sourced from https://cesaraustralia.com/resources/beneficials-toxicity-table/ accessed 21 July 2023. Wasps only include those that parasitise caterpillars, – indicates no data.

active ingredient (MoA)	e.g. Product	Lady beetles	Predatory bugs	Hover flies	Wasps	Lacewing
NPV (31)	ViVUS Max	**L**	**L**	**L**	**L**	**L**
Bt	DIPEL SC	**L**	**L**	**L**	**L**	**L**
Chlorantraniliprole (28)	Vantacor®	**L**	**L**	**L**	**L**	**L**
Indoxacarb (22A)	Steward®	**M-H**	**L-M**	**L**	**VH**	**L**
Spinetoram (5)	Success® Neo	**L-M**	**L-M**	**-**	**VH**	**M**
Methomyl (1A)	Lanate®	**VH**	**VH**	**VH**	**H**	**VH**
Synthetic Pyrethroids (3A)	Karate® Sumi-Alpha®	**H-VH**	**VH**	**H**	**VH**	**VH**
	Trojan*	**VH**	**VH**	**VH**	**VH**	**VH**

Notes: *data obtained from IOBC website as not included in Cesar results;

Biorational products

Insecticides that are relatively non-toxic with few ecological side-effects are called biorational, although there is no official definition of this term.

The major categories of biorational products include botanicals (e.g. Sero-X®), microbials (e.g. ViVUS Max), and synthetic materials (e.g. Success Neo). A knowledge of pest ecology underpins effective biorational approaches where application timing is critical for success.

Trial details from two projects demonstrating the use of biorational products to protect pulses from insect damage are given below.

ViVUS Max demonstrations 2020

Nuclear polyhedrosis virus (NPV) of *Helicoverpa armigera* (Heliothis) is the active baculovirus-based biological control in the product ViVUS Max. The baculovirus multiplies and spreads through the Heliothis population—generally lasting for the duration of the crop. ViVUS continuously suppresses the pest without causing flare-ups in other pests. ViVUS Max is registered for use in Australia to control Heliothis in pulses (APVMA Approval Number: 60905/56701). Application times were informed by monitoring with pheromones and smart traps and phenological development models.

In faba beans DTN smart traps provided real time data on adult Heliothis flights, which was then used to inform application of ViVUS Max plus Optimal®, an insecticide enhancer. A singly timely application when 1st instar larvae were projected based in development models resulted in no damage to beans. The grain quality was considered equal to conventional insecticides applied at the 3rd instar, when caterpillars can easily be detected using sweep nets. More predatory bugs were observed in this paddock where the non-disruptive ViVUS Max was applied.

Monitoring and use of a ViVUS Max was demonstrated at a 2rd paddock of peas. Weekly monitoring and poor weather saw the delayed application, which resulted in caterpillar damage to grain, hence downgrading. Application was difficult due to poor weather conditions late September 2020. Despite the increase in natural enemies at one site where less disruptive insecticides were used, the lack of tolerance for insect damage excludes the use of NPV technologies for control of native budworm in southern Australia.

Sero-X® demonstrations 2021

Cyclic peptides (Sero-X®) are an extract of *Clitoria ternatea* (Butterfly pea).

It is claimed that they:

- play various defensive roles, including pest suppression
- have 3 distinct modes of action: anti-feedant, direct mortality and as an ovipositing/oviposition deterrent.

Sero-X® is registered for use in Australia to control Heliothis in cotton (APVMA Approval No: 81070) but not broadacre pulse crops. Large scale (10 ha) paired field trials (four) were conducted in canola in southern Australia during 202largeplication times were informed by monitoring with pheromones and smart traps and phenological development models.

During the 2021 growing season, four paired field sites demonstrated to growers that Sero-X provided some control over native budworms. However, the reduction in larvae was not enough to meet zero thresholds in pulse crops. Where some damage can be tolerated, such as canola, control of budworm larvae was acceptable when applied later in the season. Control of diamondback moth was poor, especially when applied earlier in the season and control of common armyworm was not detected. Further investigation is needed to determine the influence temperature plays in Sero-X efficacy if it is to be successful in protecting crops in southern regions.

Very few natural enemies were observed during the 2021 spring. European Honeybees were observed in canola and native bees were quantified using blue vane traps with the help of the University of Adelaide entomologists. No differences in relative abundance were detected between

Sero-X and untreated areas. No conclusions can be made regarding Sero-X's impacts on beneficial species due to the low level of activity observed at demonstration sites.

Site 1 Minnipa EP - cutworm in wheat. No result due to no pest pressure (Smart trap data).

Site 2 Tarlee Mid North - common armyworm in wheat. Adult flights were detected in early May (Smart trap data) and the paddock was treated with conventional insecticide (alpha cypermethrin 50 g a.i./ha) by the grower at GS 2.5 before larvae were detected on 28th July 2021. Two L2/40 sweeps were detected on 5 Sep 2021, but no plant damage was found.

Site 2a Halbury Mid North - common armyworm in Wheat. Larvae (L2 & L3) were treated with Sero-X 1.5% at GS 3.5 (5 ha; 19 Aug 2021) no mortality was observed 7DAA so the paddock was treated with conventional insecticide by the grower at GS 3.9 (8 Sep 2021 alpha cypermethrin 60 g a.i./ha). An untreated strip was left (36m wide by 200m long) and harvest data compared with the neighbouring area treated with insecticides, no differences in wheat yield were observed. There was a negative return on investment applying an insecticide to control Armyworm at this site.
A complimentary lab trial was conducted, which found Sero-X did not cause any common armyworm mortality at 1/2, 1, or 2% dilution.

Site 3 Curramulka YP - native budworm in faba beans. Adult flights were detected (Fig 3.1, Smart Trap) and Sero-X 2% was applied with fungicides @ L2 based on their developmental model (10 ha; 27 Oct 2021). Sero-X was found to be compatible with the fungicide being applied. Pod damage and larvae were observed at 7 DAA in the treated area so the paddock was treated with conventional insecticide (7 Oct 2021 gamma-cyhalothrin 7.5 g a.i/ha) by contractor 10 DAA due to nil damage tolerance. A negative return would have been incurred due to the increased cost of Sero-X ($60 /ha vs $8 / ha) and the down grading of beans due to insect damage. (Figure 3).

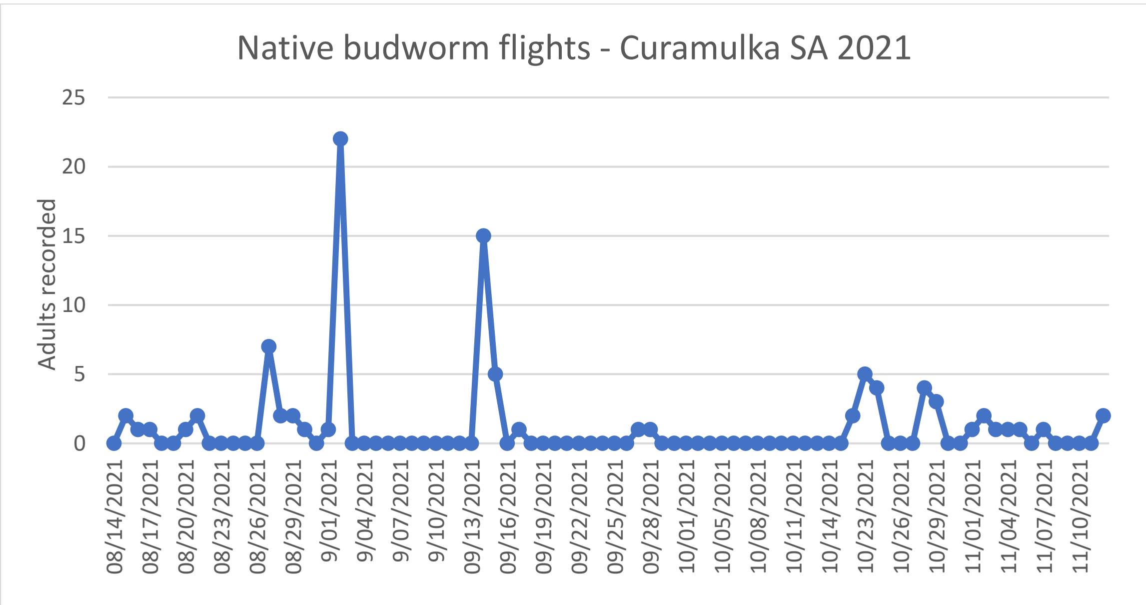

Fig 3 Native Budworm moth counts from DTN smart trap located at -34.738, 137.782 near Curramulka SA.

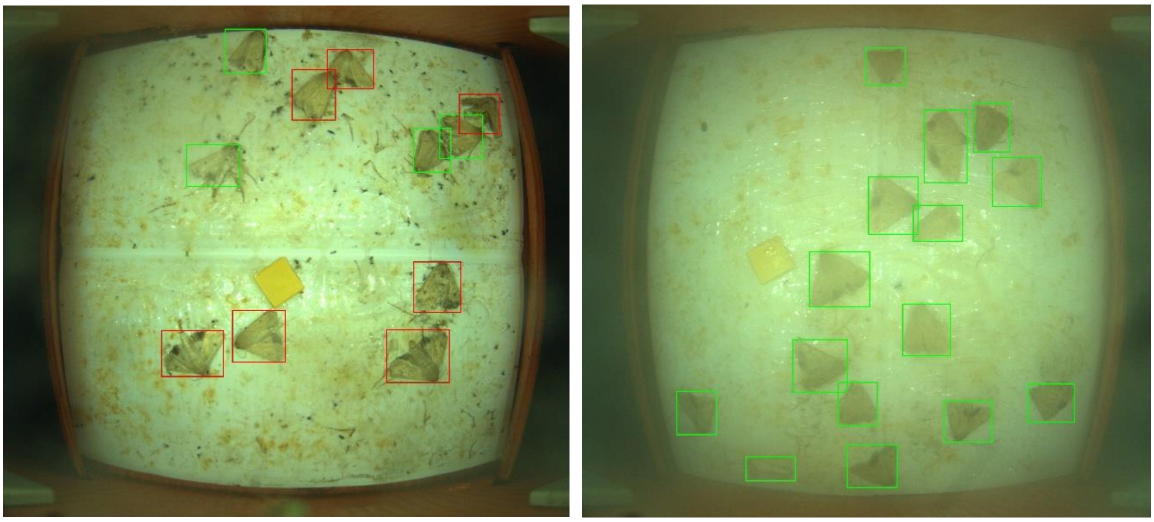

Plate 3. DTN images from a/ 14 Sep & b/24 Oct 2021. Green squares are previous days native budworm catch. Note sticky cards were changed every 2 weeks, hence very different images.

Site 4 Wangary EP - diamondback moth in canola. Adult flights were detected (Fig 4.1 Smart Trap) and Sero-X 2% was applied twice based on their developmental model (5 ha; 2 & 24 Sep 2021). A reduction in larvae (L2 & L3) might have been observed. Due to native budworm and DBM in the crop, the entire crop was treated with conventional insecticide (11 Oct 2021 lambda-cyhalothrin 9 g a.i./ha), except for the Sero-X treated area.

Yield data indicated no significant differences between the treatments: Sero-X 2.175 t/ha vs grower practice 2.225 t/ha.
Two applications of Sero-X cost $132 /ha including application costs, which is much greater than the $15 /ha for the conventional reactive grower practice using a synthetic pyrethroid to achieve the same result.

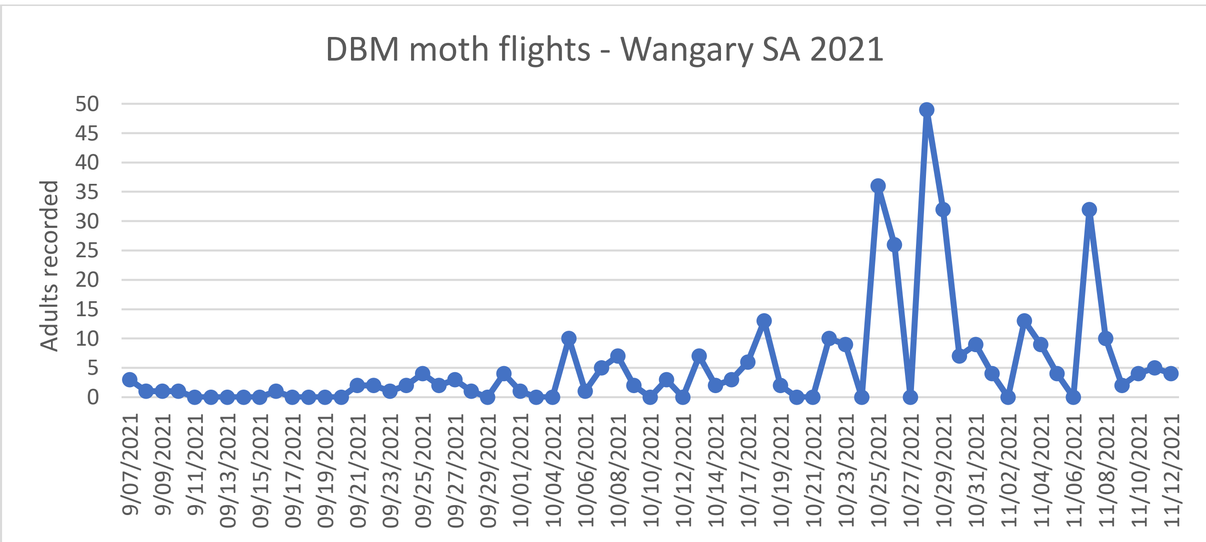

Fig 4.1 Daily Diamond Back Moth counts from DTN smart trap located at -34.4682, 135.4186 near Wangary SA

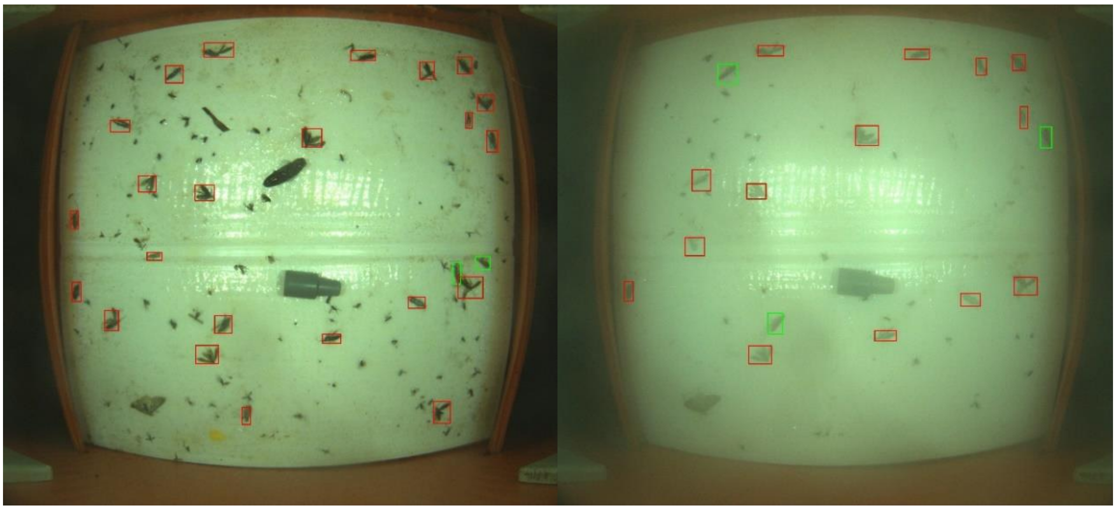

Plate 4. DTN images from a/ 7 & b/24 Sep 2021. Green squares are previous days DBM catch.

Site 5 Corny Point YP - diamondback moth in canola. Adult flights were detected (Fig. 5.1 Smart Trap) and Sero-X 2% applied (10 ha, 17 Oct 2021) well after when their developmental model suggested optimal timing. A small reduction in larvae (L3) was observed at 3 DAA & 14 DAA.

There was a significant reduction in native budworm larvae (L3 & L4) that were feeding on pods. Crows seem to be drawn to the Sero-X treated area of the paddock.

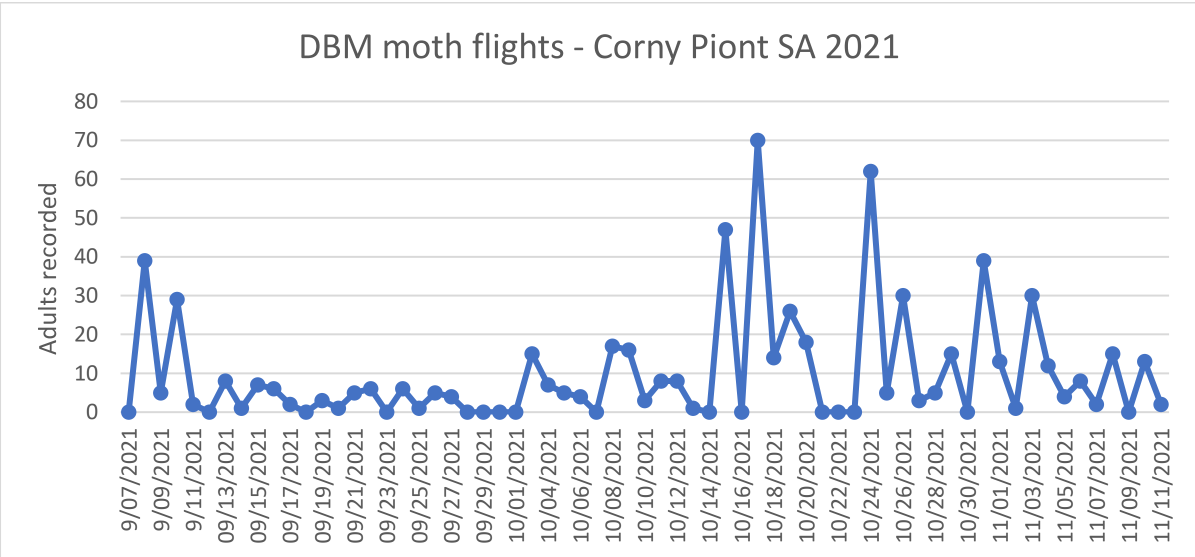

Fig 5.1 Daily Diamond Back Moth counts from DTN smart trap located at -34.999, 137.112 near Corny Point SA.

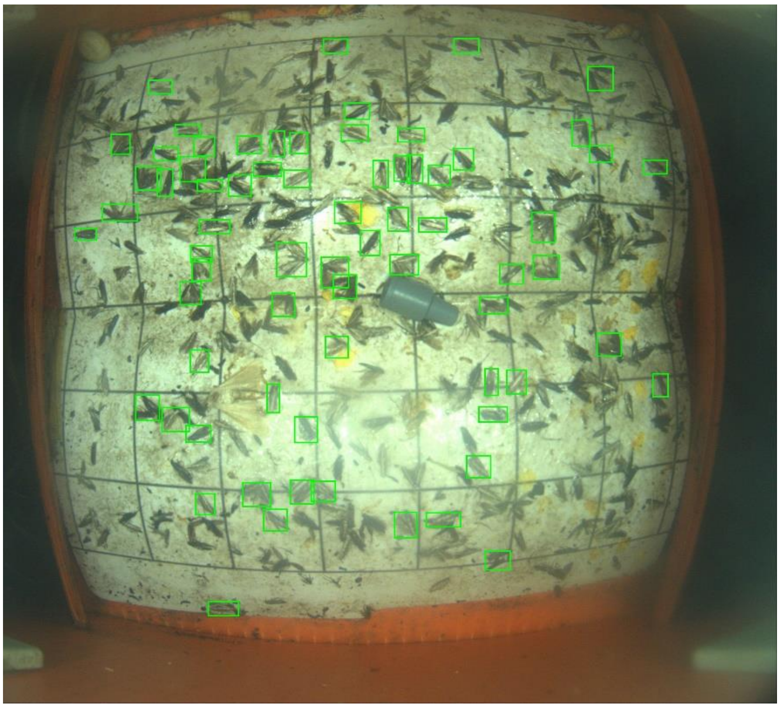

Plate 5. DTN images from 17 Oct 2021. Green squares are previous days DBM catch.

The yield was significantly greater (*P* = 0.001 in the Sero-X area: 3.4 t/ha vs 2.8 t/ha in untreated. The one-off cost of $68 returned an extra $475 /ha based on a canola price of $920 /tonne. That equates to $7 for every $1 spent on Sero-X, however a synthetic pyrethroid would have returned $26 for every $1 spent to control Heliothis in this canola crop.

In canola, some pod damage will occur before it is economic to apply a treatment, so action thresholds were based on yield loss caused by native budworm. The canola yield was significantly greater (*P* = 0.001) in the Sero-X® area (3.4 t/ha) than in the untreated area where native budworm was causing pod damage (2.8 t/ha). Protection from DBM was poor, especially when applied earlier in the season; Sero-X® 2.175 t/ha vs grower practice 2.225 t/ha (Nash, 2022). Where some damage can be tolerated, such as canola, control of budworm larvae were acceptable when applied later in the season. Control of diamondback moth was poor, especially when applied earlier in the season.

In faba beans adult flights of Heliothis were detected and Sero-X 2% was applied with fungicides @ L2 based on their developmental model. Sero-X was found to be compatible with the fungicide being applied. Pod damage and larvae were observed at 7 DAA in the treated area so the paddock was treated with conventional insecticide 10 DAA due to nil damage tolerance. A negative return would have been incurred by due to the increased cost of Sero-X ($60 /ha vs $8/ha) and the down grading of beans due to insect damage. The reduction in Heliothis larvae was not enough to meet thresholds for faba beans and control of common armyworm was not detected. Further investigation is needed to determine the influence temperature plays in Sero-X efficacy if it is to be successful in protecting crops in southern regions.

Very few natural enemies were observed during the 2021 spring. European Honeybees and native bees were quantified using blue vane traps with the help of the University of Adelaide entomologists. No differences in relative abundance were detected between Sero-X and untreated areas. No conclusions can be made regarding Sero-X's impacts on beneficial species due to the low level of activity observed at demonstration sites.

Conclusions

Demonstration trials, run in collaboration with growers, also provided insights into adoption. Several factors often limit the adoption of biorational products including that they:

- are expensive
- must be applied before the pest becomes a problem; and
- are harder to apply as you must know about the pest's ecology.

Whilst growers currently consider biorational products as less attractive options than conventional insecticides, biorational products could have an important role in mitigating the rate of insecticide resistance development and reducing off-target impacts on natural enemies while maintaining market access.

The use of conventional insecticides that are less disruptive to natural enemies need to be considered, despite their cost. Vantacor has replaced traditional synthetic pyrethroids to stop insect damage to faba beans as part of IPM in southwest Victoria. What is the true cost of continued reliance on synthetic pyrethroids?

Acknowledgements

Demonstrating best practice insect pest control in southern Australia using an innovative, safe and APVMA approved bio-active peptides that enhance biodiversity and maintain soil quality in no-till systems that are under pressure from pests is a project delivered by the SA NoTill Farmers Association with funding support from the Australian Government National Landcare Program.

SANTFA acknowledges the significant contribution of co-operating farmers, Innovate Ag for supplying Sero-X. Dr Michael Nash (https://www.researchgate.net/profile/Michael-Nash-2) was funded by Australian Government's National Landcare Program through Community Action Grants provided by the Northern and Yorke Landscape.